Virtual autopsy in fetuses and newborn

B. Bessières
F. Raimondi, D. Bonnet
Post mortem examination

- PM examination plays an important role
  - genetic counselling
  - quality control of prenatal sonographic examination

- Classical autopsy as gold standard
- Decreasing rate in acceptance of classical autopsy (France / UK)
  - Cultural / Religious Objections

-Virtuopsy as non-invasive alternative to classical autopsy
Post mortem imaging

- MRI
  - Brain
  - Chest,
    - Abdomen
    -( Cardiovascular system)

- CTscan
  - Skeletal diseases

- CT angiography
  - Cardiovascular system
Acceptance, reliability and confidence of reporting fetal and neonatal virtuopsy as compared to conventional necroscopy: a prospective study

- n = 96 women (102 fetuses) with TOP or IUFD

- Both classical autopsy and virtuopsy (1.5T MRI or CT scan) were offered

- Effect on the acceptance for a virtuopsy and classical autopsy of
  - the age of the patient
  - GA at termination
  - twinning
  - parity
  - educational level
  - religion
  - care giver taking consent
  - reason for death.

Cannie et al UOG 2012
“Classical PM” vs “Virtuopsy”: Acceptance

96 patients following TOP or neonatal death

99 % (95/96)

62.5 % (60/96)
“Classical PM” vs “Virtuopsy”: Acceptance

- GA @ TOP: < 20, 20-29, ≥ 30
- Cult: Muslim, Non-Muslim
- Care giver taking consent: MFM, Non MFM
“Classical PM” vs “Virtuopsy”

Post-mortem examination of human fetuses: a comparison of whole-body high-field MRI at 9·4 T with conventional MRI and invasive autopsy.

Tayyil et al. The Lancet, Volume 374, Issue 9688, Pages 467 - 475, 8 August 2009
Thayyil et Al (Lancet 2009):

• high-field 9.4T MRI in examining fetuses as early as 11 weeks of gestation.
• high field MRI at 9.4T provided greater spatial resolution, an higher tissue contrast than 1.5 T
• diagnostic accuracy of fetal structural abnormalities seems equivalent to invasive autopsy
• only 1 case with congenital Heart Disease, associated with diaphragmatic hernia.
“Virtuopsy” < 20 weeks of GA: High-field MRI at 9.4 T

Fetus at 14 weeks of GA with normal cardiac anatomy

MRI at 1.5 T
“Virtuopsy” < 20 weeks of GA: High-field MRI at 9.4 T

Fetus at 14 weeks of GA; High-field MRI at 9.4 T
“Virtuopsy” < 20 weeks of GA: Diagnostic accuracy of PM MRI
Post-mortem examination of human fetal heart in the first half of the pregnancy:
a comparison of high-field MRI at 9.4T to lower-field MRI magnets and the stereomicroscopic autopsy

• $n = 24$ fetuses at 11-20 weeks of GA (4-310 grams)

22 with various chromosomal or structural abnormalities, 2 miscarriages

• 10 fetuses with cardiac abnormalities

• Post mortem MRI at 9.4 T, 3.0 T and 1.5 T as well as stereomicroscopic autopsy within 24 hours

• Were evaluated our ability to visualize different heart structures according to the different field strength MRI magnets used and to the GA at examination

• as well as the diagnostic usefulness of high-field MRI for cardiac abnormalities

C.Votino, B.Bessieres, M.Cannie, M.Verhoye, J.Jani   UOG 2012
“Virtuopsy” < 20 weeks of GA:
Ability to visualize heart structures

%
“Virtuopsy” < 20 weeks of GA: Ability to visualize heart structures
“Virtuopsy” < 20 weeks of GA: Diagnostic accuracy of PM MRI

7 out of 8 CHD detected

19 weeks GA
“Virtuopsy” < 20 weeks of GA: Diagnostic accuracy of PM MRI

Hypoplastic Right Ventricle

16 WG, 100 gr, TOP for cystic hygroma and CHD
“Virtuopsy” < 20 weeks of GA: Diagnostic accuracy of PM MRI

AVSD
RA

14 WG, 40 gr
TOP for Down’s syndrome
“Virtuopsy” < 20 weeks of GA: Diagnostic accuracy of PM MRI

AVSD, VSD

14 WG, 40 gr
TOP for Down’s syndrome
“Virtuopsy” < 20 weeks of GA: Diagnostic accuracy of PM MRI

11 WG, 4.33 grams, miscarriage with normal caryotype
PM MRI in fetuses with CHD

• MRI 9.4 T analyse cardiac structure since 11 GA with high sensibility and specificity

• 7 of 8 cardiac anomalies were detected by MRI 9.4 T

• MRI 1.5 and 3T is not capable to visualize cardiac structures before 16 GA and only 4-chamber after 16 GA
“Virtuopsy” > 18 weeks of GA: CT angiography

Minimally invasive postmortem CT angiography in a human corpse

Dirnhofer R et al. Radiographics 2006; 26: 1305-1333


Virtuopsy by CT angiography in fetal heart: a feasibility study

N= 33 fetuses following (26 TOP and 7 IUFD > 18 weeks of GA
(6 with CHD) N= 25

Votino et al, UOG 2012
“Virtuopsy” > 18 weeks of GA:
CT angiography
“Virtuopsy” > 18 weeks of GA: CT angiography

Normal aortic arch  Right aortic arch  Coarctation of aorta
# Fetuses with CHD

<table>
<thead>
<tr>
<th>Case</th>
<th>Malformation</th>
<th>GA at TOP (weeks)</th>
<th>Fetal weight (g)</th>
<th>Findings on prenatal ultrasound</th>
<th>Findings on post-CT angiography</th>
<th>Findings on invasive autopsy</th>
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<tbody>
<tr>
<td>9</td>
<td>Ebstein cardiopathy</td>
<td>24.3</td>
<td>613</td>
<td>Ebstein cardiopahy</td>
<td>Ebstein cardiopathy</td>
<td>Ebstein cardiopathy</td>
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<tr>
<td>12</td>
<td>Trisomy 18</td>
<td>31.1</td>
<td>1167</td>
<td>VSD</td>
<td>Normal</td>
<td>VSD</td>
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<td>17</td>
<td>Polymalformation</td>
<td>26.6</td>
<td>1372</td>
<td>AVSD and aortic atresia</td>
<td>Not diagnostic owing to leakage into pleural cavity</td>
<td>AVSD and aortic atresia</td>
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<tr>
<td>19</td>
<td>Di George syndrome</td>
<td>25.4</td>
<td>—</td>
<td>Right aortic arch</td>
<td>Right aortic arch</td>
<td>Not available</td>
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<tr>
<td>31</td>
<td>Trisomy 13</td>
<td>18.0</td>
<td>108</td>
<td>AVSD, hypoplasia left ventricle and ascending aorta</td>
<td>Normal</td>
<td>VSD</td>
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<tr>
<td>33</td>
<td>Isomerism</td>
<td>24.3</td>
<td>552</td>
<td>Hypoplasia left ventricle and interruption of aorta</td>
<td>Hypoplasia left ventricle and coarctation of aorta</td>
<td>Hypoplasia left ventricle and coarctation of aorta</td>
</tr>
</tbody>
</table>

AVSD, atrioventricular septal defect; GA, gestational age; VSD, ventricular septal defect.
CT in postmortem examination

- Virtual autopsy using pm-CT angiography is promising as an alternative approach for the examination of fetal heart > 18 weeks of GA
Necker experience

• 23 fetuses between 24 and 36 GA
• All informed consent for virtual and conventional autopsy
• CT scan with 64 multislices detector
• Injection of contrast medium (20%)
• 8 intracardiac, 15 intra umbilical cord (up to 60 ml)
<table>
<thead>
<tr>
<th></th>
<th>GE</th>
<th>Cardiac anomalies</th>
<th>Other anomalies</th>
<th>Final diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
<td>Normal heart</td>
<td>Uropathy</td>
<td>VUP</td>
</tr>
<tr>
<td>2</td>
<td>37</td>
<td>Aortic coarctation, LSVC</td>
<td>Dysmorphoy</td>
<td>Pierre Robin Sdr, HCD</td>
</tr>
<tr>
<td>3</td>
<td>35</td>
<td>Shone syndrome</td>
<td>Dysmorphoy, Cerebral anomalies, SCC absent, coloboma</td>
<td>Charge</td>
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<tr>
<td>4</td>
<td>24</td>
<td>Dextrocardie, SLL, straddling TV</td>
<td>Pulmonary isomerism, facial anomalies</td>
<td>Heterotaxia</td>
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<tr>
<td>5</td>
<td>26</td>
<td>Fallot, PAPVR, LSVC</td>
<td>Polysplenia, abdominal anomalies</td>
<td>Heterotaxia</td>
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<tr>
<td>6</td>
<td>29</td>
<td>TAC</td>
<td>No</td>
<td>Isolated CHD</td>
</tr>
<tr>
<td>7</td>
<td>36</td>
<td>TGA + VSD</td>
<td>No</td>
<td>Isolated CHD</td>
</tr>
<tr>
<td>8</td>
<td>25</td>
<td>DORV, complex venous anomalies</td>
<td>Polysplenia, left liver</td>
<td>Heterotaxia</td>
</tr>
</tbody>
</table>
# Population

<table>
<thead>
<tr>
<th>GE</th>
<th>Cardiac anomalies</th>
<th>Other anomalies</th>
<th>Final diagnosis</th>
</tr>
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<tbody>
<tr>
<td>9</td>
<td>Shone syndrome</td>
<td>No</td>
<td>Isolated CHD</td>
</tr>
<tr>
<td>10</td>
<td>APSI</td>
<td>Ureteral duplication</td>
<td>Polymalformation</td>
</tr>
<tr>
<td>11</td>
<td>TGA</td>
<td>No</td>
<td>Isolated CHD</td>
</tr>
<tr>
<td>12</td>
<td>TGA</td>
<td>No</td>
<td>Isolated CHD</td>
</tr>
<tr>
<td>13</td>
<td>APSO+MAPCAs</td>
<td>No</td>
<td>Isolated CHD</td>
</tr>
<tr>
<td>1417</td>
<td>....</td>
<td></td>
<td>...</td>
</tr>
</tbody>
</table>
Normal Heart, 25 GE, IC
Normal Heart, 25 GE, IC
Aortic coarctation, 35 GE, IUc
Aortic coarctation, 35 GE, IUc
Aortic coarctation, 35 GE, IUc
Shone syndrome, 24 GE, Ic
DORV, 26 GE, IUc
DORV, 26 GE, IUc
DORV, 26 GE, IUc
TGA +VSD, 36 GE, IC+IUc
TGA +VSD, 36 GE, IC+IUc
TGA + VSD, 36 GE, IC+IUc
TGA + VSD, 36 GE, IC+IUc

Ao

AP
TGA + VSD, 36 GE, IC+IUc
PA+VSD+MAPCAs, 24 GE, IUc
Ao Hypo + LSVC IUc

FOETUS
XXXX 30/05/2013 M
Cardiac Ungated Nat Fill HU Normal [inS...
Hospital Necker BAT
AXIOM-Artis
30/05/2013
18:53:49
AX

SHADE/SURF
A
OAG/OAD -4
CRAN/CAUD -1

B 100 W 868
O 80 C 858
Conclusion

Classical autopsy as a gold standard

- Virtuopsy is a real alternative to classical autopsy
- MRI 9.4 T from 11 sa
- MRI 1.5T after 20 GA for Brain, chest, abdomen
- Ctscan for squeletal and for cardiovascular system after 18 GA
Merci pour votre attention...